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Title: Investigation of Region-wise Sensitivities for Nuclear Criticality Safety Validation

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Investigation of Region-wise Sensitivities for Nuclear Criticality Safety Validation

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Los Alamos National Laboratory

August 9, 2018

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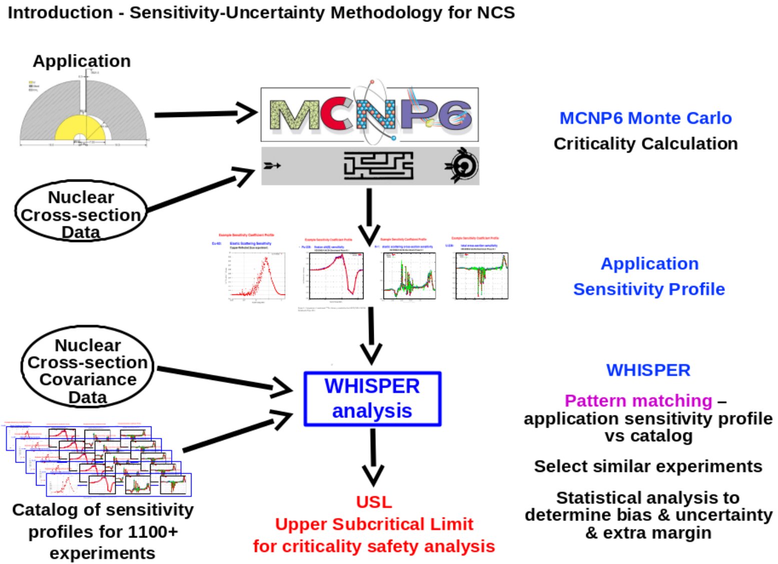
Whisper 1.1 Overview

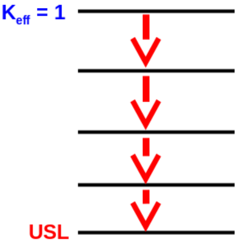


Whisper 1.1 Overview

Introduction – NCS validation

Upper Subcritical Limit (USL)

- **For an application:**
  - **A calculated $K_{eff} < 1.0$ is NOT sufficient to ensure subcriticality**
  - **Must conservatively account for**
    - Bias & uncertainties in the calculational method
    - Uncertainties in the physical model (eg, mass, isotopics, geometry, ...)



Bias = mean $(K_{calc} - K_{exp})$ for a set of experiments that are similar to the application

Bias Uncertainty, at 95% or 99% confidence level

Margin of Subcriticality (MOS) = code & data uncertainties

MOS for Area of Applicability (AOA) = if benchmarks are not similar enough to application

$$\textbf{Must have:} \quad K_{calc} + 2\sigma_{calc} < \text{USL}$$

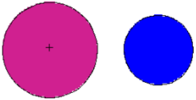
Numerical Study Methodology

This numerical study explores how Whisper selects benchmark populations and determines the baseline USL for various loosely coupled systems.

The following steps outline the methodology of this study:

- Models of four distinct loosely-coupled systems were created
- A parametric study of five separating distances between assemblies was conducted for each model
- Region-wise and overall system sensitivity profiles are developed by MCNP6.2.0
- Whisper 1.1 selected benchmark populations for the sensitivity profiles and determines a baseline USL for the sensitivity profile
- Truncated benchmark profiles and baseline USL values are compared between the two regions and the overall system for each model

Fast Bare Metal Sphere Model Overview



Fast Bare Metal Sphere Model Results

Bare fast Plutonium Sphere Ranked Benchmark	Separation Distance [cm] 20	40	60	80	100
1	pu-met-fast-001-001.i	pu-met-fast-001-001.i	pu-met-fast-001-001.i	pu-met-fast-001-001.i	pu-met-fast-001-001.i
2	pu-met-fast-022-001.i	pu-met-fast-022-001.i	pu-met-fast-022-001.i	pu-met-fast-022-001.i	pu-met-fast-022-001.i
3	pu-met-fast-029-001.i	pu-met-fast-029-001.i	pu-met-fast-029-001.i	pu-met-fast-029-001.i	pu-met-fast-029-001.i
4	mix-met-fast-009-001.i	mix-met-fast-009-001.i	mix-met-fast-009-001.i	mix-met-fast-009-001.i	mix-met-fast-009-001.i
5	pu-met-fast-023-001.i	pu-met-fast-023-001.i	pu-met-fast-023-001.i	pu-met-fast-023-001.i	pu-met-fast-023-001.i
6	pu-met-fast-035-001.i	pu-met-fast-035-001.i	pu-met-fast-035-001.i	pu-met-fast-035-001.i	pu-met-fast-035-001.i
7	pu-met-fast-039-001.i	pu-met-fast-039-001.i	pu-met-fast-039-001.i	pu-met-fast-039-001.i	pu-met-fast-039-001.i
8	pu-met-fast-030-001.i	pu-met-fast-030-001.i	pu-met-fast-030-001.i	pu-met-fast-030-001.i	pu-met-fast-030-001.i
9	pu-met-fast-009-001.i	pu-met-fast-009-001.i	pu-met-fast-009-001.i	pu-met-fast-009-001.i	pu-met-fast-009-001.i
10	pu-met-fast-025-001.i	pu-met-fast-025-001.i	pu-met-fast-025-001.i	pu-met-fast-025-001.i	pu-met-fast-025-001.i

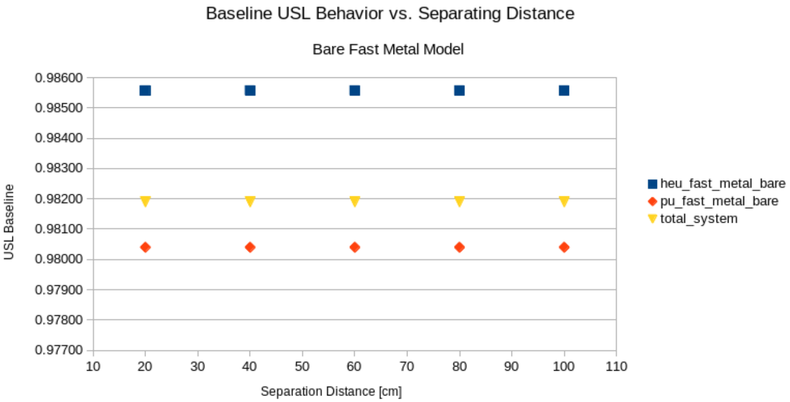
Fast Bare Metal Sphere Model Results

Bare Fast HEU Sphere Ranked Benchmark	Separation Distance [cm] 20	40	60	80	100
1	heu-met-fast-051-015.i	heu-met-fast-051-015.i	heu-met-fast-051-015.i	heu-met-fast-051-015.i	heu-met-fast-051-015.i
2	heu-met-fast-100-002.i	heu-met-fast-100-002.i	heu-met-fast-100-002.i	heu-met-fast-100-002.i	heu-met-fast-100-002.i
3	heu-met-fast-051-014.i	heu-met-fast-051-014.i	heu-met-fast-051-014.i	heu-met-fast-051-014.i	heu-met-fast-051-014.i
4	heu-met-fast-100-001.i	heu-met-fast-100-001.i	heu-met-fast-100-001.i	heu-met-fast-100-001.i	heu-met-fast-100-001.i
5	heu-met-fast-065-002.i	heu-met-fast-065-002.i	heu-met-fast-065-002.i	heu-met-fast-065-002.i	heu-met-fast-065-002.i
6	heu-met-fast-044-001.i	heu-met-fast-044-001.i	heu-met-fast-044-001.i	heu-met-fast-044-001.i	heu-met-fast-044-001.i
7	heu-met-fast-001-001.i	heu-met-fast-001-001.i	heu-met-fast-001-001.i	heu-met-fast-001-001.i	heu-met-fast-001-001.i
8	heu-met-fast-015-001.i	heu-met-fast-015-001.i	heu-met-fast-015-001.i	heu-met-fast-015-001.i	heu-met-fast-015-001.i
9	heu-met-fast-008-001.i	heu-met-fast-008-001.i	heu-met-fast-008-001.i	heu-met-fast-008-001.i	heu-met-fast-008-001.i
10	heu-met-fast-044-002.i	heu-met-fast-044-002.i	heu-met-fast-044-002.i	heu-met-fast-044-002.i	heu-met-fast-044-002.i

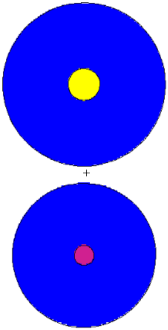
Fast Bare Metal Sphere Model Results

Bare Fast Metal System Ranked Benchmark	Separation Distance [cm] 20	40	60	80	100
1	mix-met-fast-007-013.i	mix-met-fast-007-013.i	mix-met-fast-007-013.i	mix-met-fast-007-013.i	mix-met-fast-007-013.i
2	mix-met-fast-007-012.i	mix-met-fast-007-012.i	mix-met-fast-007-012.i	mix-met-fast-007-012.i	mix-met-fast-007-012.i
3	mix-met-fast-007-018.i	mix-met-fast-007-018.i	mix-met-fast-007-018.i	mix-met-fast-007-018.i	mix-met-fast-007-018.i
4	mix-met-fast-007-011.i	mix-met-fast-007-011.i	mix-met-fast-007-011.i	mix-met-fast-007-011.i	mix-met-fast-007-011.i
5	mix-met-fast-010-001.i	mix-met-fast-010-001.i	mix-met-fast-010-001.i	mix-met-fast-010-001.i	mix-met-fast-010-001.i
6	mix-met-fast-007-006.i	mix-met-fast-007-006.i	mix-met-fast-007-006.i	mix-met-fast-007-006.i	mix-met-fast-007-006.i
7	mix-met-fast-007-017.i	mix-met-fast-007-017.i	mix-met-fast-007-017.i	mix-met-fast-007-017.i	mix-met-fast-007-017.i
8	mix-met-fast-007-005.i	mix-met-fast-007-005.i	mix-met-fast-007-005.i	mix-met-fast-007-005.i	mix-met-fast-007-005.i
9	mix-met-fast-007-010.i	mix-met-fast-007-010.i	mix-met-fast-007-010.i	mix-met-fast-007-010.i	mix-met-fast-007-010.i
10	mix-met-fast-007-021.i	mix-met-fast-007-021.i	mix-met-fast-007-021.i	mix-met-fast-007-021.i	mix-met-fast-007-021.i

Fast Bare Metal Sphere Model Results



Water-Reflected Fast Metal Sphere Model Overview



Water-Reflected Fast Metal Sphere Model Results

Reflected Fast HEU Metal Sphere Ranked Benchmark	Separation Distance [cm] 40	60	80	100	120
1	heu-met-fast-004-001.i	heu-met-fast-004-001.i	heu-met-fast-004-001.i	heu-met-fast-004-001.i	heu-met-fast-004-001.i
2	heu-met-fast-078-001.i	heu-met-fast-078-001.i	heu-met-fast-078-001.i	heu-met-fast-078-001.i	heu-met-fast-078-001.i
3	heu-met-fast-011-001.i	heu-met-fast-011-001.i	heu-met-fast-011-001.i	heu-met-fast-007-035.i	heu-met-fast-084-011.i
4	heu-met-fast-007-035.i	heu-met-fast-084-011.i	heu-met-fast-007-035.i	heu-met-fast-011-001.i	heu-met-fast-011-001.i
5	heu-met-fast-078-011.i	heu-met-fast-007-035.i	heu-met-fast-078-011.i	heu-met-fast-091-001.i	heu-met-fast-016-002.i
6	heu-met-fast-078-009.i	heu-met-fast-016-002.i	heu-met-fast-078-017.i	heu-met-fast-078-011.i	heu-met-fast-084-002.i
7	heu-met-fast-078-017.i	heu-met-fast-091-001.i	heu-met-fast-078-009.i	heu-met-fast-078-017.i	heu-met-fast-078-005.i
8	heu-met-fast-078-005.i	heu-met-fast-078-005.i	heu-met-fast-078-005.i	heu-met-fast-078-009.i	heu-met-fast-009-002.i
9	heu-met-fast-078-015.i	heu-met-fast-078-017.i	heu-met-fast-078-015.i	heu-met-fast-078-005.i	heu-met-fast-078-017.i
10	heu-met-fast-078-013.i	heu-met-fast-078-011.i	heu-met-fast-078-013.i	heu-met-fast-078-015.i	heu-met-fast-010-002.i

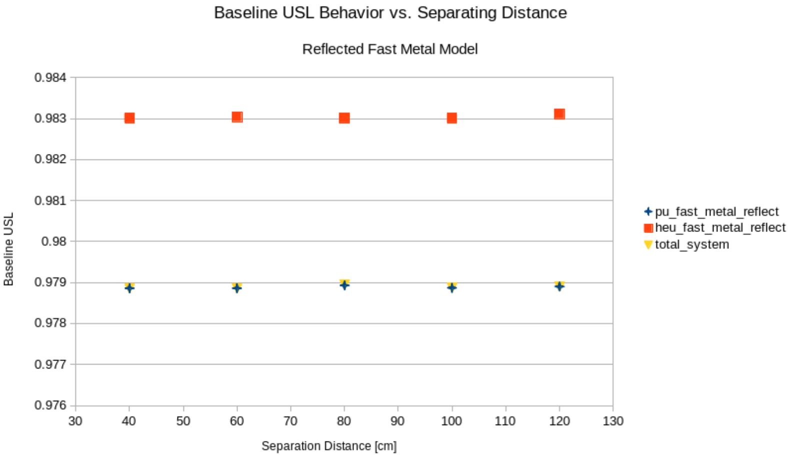
Water-Reflected Fast Metal Sphere Model Results

Reflected Fast Plutonium Metal Sphere Ranked Benchmark	Separation Distance [cm] 40	60	80	100	120
1	pu-met-fast-011-001.i	pu-met-fast-011-001.i	pu-met-fast-011-001.i	pu-met-fast-011-001.i	pu-met-fast-011-001.i
2	pu-met-fast-044-004.i	pu-met-fast-042-001.i	pu-met-fast-042-001.i	pu-met-fast-044-004.i	pu-met-fast-044-004.i
3	pu-met-fast-042-001.i	pu-met-fast-044-004.i	pu-met-fast-044-004.i	pu-met-fast-042-001.i	pu-met-fast-042-001.i
4	pu-met-fast-027-001.i	pu-met-fast-027-001.i	pu-met-fast-042-002.i	pu-met-fast-027-001.i	pu-met-fast-027-001.i
5	pu-met-fast-042-002.i	pu-met-fast-042-002.i	pu-met-fast-027-001.i	pu-met-fast-042-002.i	pu-met-fast-042-002.i
6	pu-met-fast-031-001.i	pu-met-fast-031-001.i	pu-met-fast-031-001.i	pu-met-fast-031-001.i	pu-met-fast-031-001.i
7	pu-met-fast-044-005.i	pu-met-fast-044-005.i	pu-met-fast-044-005.i	pu-met-fast-044-005.i	pu-met-fast-044-005.i
8	pu-met-fast-042-003.i	pu-met-fast-042-003.i	pu-met-fast-042-003.i	pu-met-fast-042-003.i	pu-met-fast-042-003.i
9	pu-met-fast-042-004.i	pu-met-fast-042-004.i	pu-met-fast-042-004.i	pu-met-fast-042-004.i	pu-met-fast-042-004.i
10	pu-met-fast-036-001.i	pu-met-fast-036-001.i	pu-met-fast-036-001.i	pu-met-fast-036-001.i	pu-met-fast-036-001.i

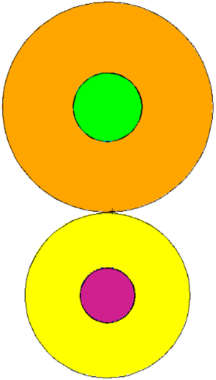
Water-Reflected Fast Metal Sphere Model Results

Reflected Fast Metal Sphere Model / Ranked Benchmark	Separation Distance [cm] 40	60	80	100	120
1	pu-met-fast-011-001.i	pu-met-fast-011-001.i	pu-met-fast-011-001.i	pu-met-fast-011-001.i	pu-met-fast-011-001.i
2	pu-met-fast-042-001.i	pu-met-fast-042-001.i	pu-met-fast-042-001.i	pu-met-fast-044-004.i	pu-met-fast-042-001.i
3	pu-met-fast-044-004.i	pu-met-fast-027-001.i	pu-met-fast-027-001.i	pu-met-fast-042-001.i	pu-met-fast-044-004.i
4	pu-met-fast-027-001.i	pu-met-fast-044-004.i	pu-met-fast-044-004.i	pu-met-fast-027-001.i	pu-met-fast-027-001.i
5	pu-met-fast-042-002.i	pu-met-fast-042-002.i	pu-met-fast-042-002.i	pu-met-fast-042-002.i	pu-met-fast-042-002.i
6	pu-met-fast-031-001.i	pu-met-fast-031-001.i	pu-met-fast-031-001.i	pu-met-fast-031-001.i	pu-met-fast-031-001.i
7	pu-met-fast-044-005.i	pu-met-fast-044-005.i	pu-met-fast-044-005.i	pu-met-fast-044-005.i	pu-met-fast-044-005.i
8	pu-met-fast-042-003.i	pu-met-fast-042-003.i	pu-met-fast-042-003.i	pu-met-fast-042-003.i	pu-met-fast-042-003.i
9	pu-met-fast-042-004.i	pu-met-fast-042-004.i	pu-met-fast-042-004.i	pu-met-fast-042-004.i	pu-met-fast-042-004.i
10	pu-met-fast-036-001.i	pu-met-fast-036-001.i	pu-met-fast-036-001.i	pu-met-fast-036-001.i	pu-met-fast-036-001.i

Water-Reflected Fast Metal Sphere Model Results



Thermal Solution Model Overview



Thermal Solution Model Results

Thermal HEU Solution Ranked Benchmark	Separation Distance [cm] 45	65	85	105	125
1	heu-sol-therm-050-010.i	heu-sol-therm-050-010.i	heu-sol-therm-050-010.i	heu-sol-therm-050-010.i	heu-sol-therm-050-010.i
2	heu-sol-therm-050-001.i	heu-sol-therm-050-001.i	heu-sol-therm-050-001.i	heu-sol-therm-050-001.i	heu-sol-therm-050-001.i
3	heu-sol-therm-050-008.i	heu-sol-therm-050-008.i	heu-sol-therm-050-008.i	heu-sol-therm-050-008.i	heu-sol-therm-050-008.i
4	heu-sol-therm-050-002.i	heu-sol-therm-050-002.i	heu-sol-therm-050-002.i	heu-sol-therm-050-002.i	heu-sol-therm-050-002.i
5	heu-sol-therm-050-004.i	heu-sol-therm-050-004.i	heu-sol-therm-050-004.i	heu-sol-therm-050-004.i	heu-sol-therm-050-004.i
6	heu-sol-therm-050-006.i	heu-sol-therm-050-006.i	heu-sol-therm-050-006.i	heu-sol-therm-050-006.i	heu-sol-therm-050-006.i
7	heu-sol-therm-009-001.i	heu-sol-therm-009-001.i	heu-sol-therm-009-001.i	heu-sol-therm-009-001.i	heu-sol-therm-009-001.i
8	heu-sol-therm-009-002.i	heu-sol-therm-050-011.i	heu-sol-therm-009-002.i	heu-sol-therm-050-011.i	heu-sol-therm-050-011.i
9	heu-sol-therm-050-011.i	heu-sol-therm-009-002.i	heu-sol-therm-050-011.i	heu-sol-therm-009-002.i	heu-sol-therm-009-002.i
10	heu-sol-therm-050-003.i	heu-sol-therm-050-005.i	heu-sol-therm-050-009.i	heu-sol-therm-050-005.i	heu-sol-therm-050-005.i

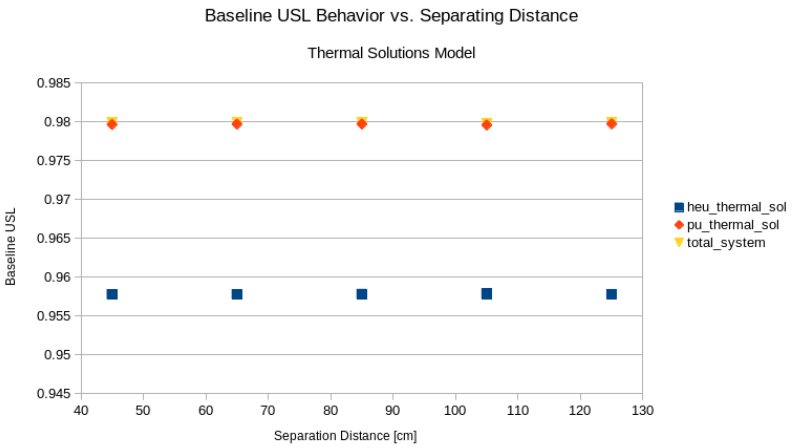
Thermal Solution Model Results

Thermal Plutonium Solution Ranked Benchmark	Separation Distance [cm] 45	65	85	105	125
1	pu-sol-therm-001-001.i	pu-sol-therm-001-001.i	pu-sol-therm-001-001.i	pu-sol-therm-001-001.i	pu-sol-therm-001-001.i
2	pu-sol-therm-002-005.i	pu-sol-therm-011-165.i	pu-sol-therm-011-165.i	pu-sol-therm-002-005.i	pu-sol-therm-010-009.i
3	pu-sol-therm-010-009.i	pu-sol-therm-010-009.i	pu-sol-therm-010-009.i	pu-sol-therm-010-009.i	pu-sol-therm-002-005.i
4	pu-sol-therm-011-165.i	pu-sol-therm-002-005.i	pu-sol-therm-002-005.i	pu-sol-therm-010-002.i	pu-sol-therm-011-165.i
5	pu-sol-therm-010-002.i	pu-sol-therm-010-002.i	pu-sol-therm-010-002.i	pu-sol-therm-011-165.i	pu-sol-therm-010-002.i
6	pu-sol-therm-002-006.i	pu-sol-therm-002-006.i	pu-sol-therm-002-004.i	pu-sol-therm-002-006.i	pu-sol-therm-002-004.i
7	pu-sol-therm-002-007.i	pu-sol-therm-002-004.i	pu-sol-therm-002-006.i	pu-sol-therm-002-007.i	pu-sol-therm-002-006.i
8	pu-sol-therm-002-004.i	pu-sol-therm-002-007.i	pu-sol-therm-002-007.i	pu-sol-therm-002-004.i	pu-sol-therm-002-007.i
9	pu-sol-therm-002-003.i	pu-sol-therm-002-003.i	pu-sol-therm-002-003.i	pu-sol-therm-002-003.i	pu-sol-therm-002-003.i
10	pu-sol-therm-001-002.i	pu-sol-therm-001-002.i	pu-sol-therm-001-002.i	pu-sol-therm-001-002.i	pu-sol-therm-001-002.i

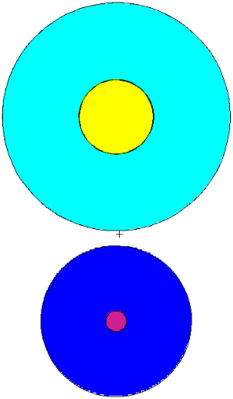
Thermal Solution Model Results

Thermal Solution Model Ranked Benchmark	Separation Distance [cm] 45	65	85	105	125
1	pu-sol-therm-001-001.i	pu-sol-therm-001-001.i	pu-sol-therm-001-001.i	pu-sol-therm-001-001.i	pu-sol-therm-001-001.i
2	pu-sol-therm-007-010.i	pu-sol-therm-010-002.i	pu-sol-therm-010-002.i	pu-sol-therm-010-002.i	pu-sol-therm-010-002.i
3	pu-sol-therm-010-002.i	pu-sol-therm-007-010.i	pu-sol-therm-007-010.i	pu-sol-therm-007-010.i	pu-sol-therm-007-010.i
4	pu-sol-therm-002-006.i	pu-sol-therm-010-009.i	pu-sol-therm-010-009.i	pu-sol-therm-010-009.i	pu-sol-therm-010-009.i
5	pu-sol-therm-010-009.i	pu-sol-therm-002-006.i	pu-sol-therm-002-006.i	pu-sol-therm-002-006.i	pu-sol-therm-002-006.i
6	pu-sol-therm-002-005.i	pu-sol-therm-002-005.i	pu-sol-therm-002-005.i	pu-sol-therm-002-005.i	pu-sol-therm-002-005.i
7	pu-sol-therm-007-005.i	pu-sol-therm-007-005.i	pu-sol-therm-002-004.i	pu-sol-therm-002-004.i	pu-sol-therm-007-005.i
8	pu-sol-therm-007-009.i	pu-sol-therm-002-004.i	pu-sol-therm-007-005.i	pu-sol-therm-001-002.i	pu-sol-therm-002-004.i
9	pu-sol-therm-001-002.i	pu-sol-therm-001-002.i	pu-sol-therm-001-002.i	pu-sol-therm-007-005.i	pu-sol-therm-001-002.i
10	pu-sol-therm-007-007.i	pu-sol-therm-007-009.i	pu-sol-therm-007-007.i	pu-sol-therm-007-007.i	pu-sol-therm-007-009.i

Thermal Solution Model Results



Mixed Plutonium Model Overview



Mixed Plutonium Model Results

Reflected Fast Plutonium Sphere Ranked Benchmark	Separation Distance [cm] 50	70	90	110	130
1	pu-sol-therm-001-001.i	pu-sol-therm-001-001.i	pu-sol-therm-001-001.i	pu-sol-therm-001-001.i	pu-sol-therm-001-001.i
2	pu-sol-therm-010-009.i	pu-sol-therm-011-165.i	pu-sol-therm-011-165.i	pu-sol-therm-011-165.i	pu-sol-therm-011-165.i
3	pu-sol-therm-011-165.i	pu-sol-therm-010-009.i	pu-sol-therm-010-009.i	pu-sol-therm-010-009.i	pu-sol-therm-010-009.i
4	pu-sol-therm-010-002.i	pu-sol-therm-002-005.i	pu-sol-therm-002-005.i	pu-sol-therm-002-005.i	pu-sol-therm-002-005.i
5	pu-sol-therm-002-005.i	pu-sol-therm-010-002.i	pu-sol-therm-010-002.i	pu-sol-therm-010-002.i	pu-sol-therm-010-002.i
6	pu-sol-therm-002-004.i	pu-sol-therm-002-004.i	pu-sol-therm-002-006.i	pu-sol-therm-002-004.i	pu-sol-therm-002-004.i
7	pu-sol-therm-002-006.i	pu-sol-therm-002-006.i	pu-sol-therm-002-004.i	pu-sol-therm-002-006.i	pu-sol-therm-002-006.i
8	pu-sol-therm-002-007.i	pu-sol-therm-002-007.i	pu-sol-therm-002-007.i	pu-sol-therm-002-003.i	pu-sol-therm-002-003.i
9	pu-sol-therm-002-003.i	pu-sol-therm-002-003.i	pu-sol-therm-002-003.i	pu-sol-therm-002-007.i	pu-sol-therm-002-007.i
10	pu-sol-therm-001-002.i	pu-sol-therm-001-002.i	pu-sol-therm-001-002.i	pu-sol-therm-011-163.i	pu-sol-therm-011-163.i

Mixed Plutonium Model Results

Thermal Plutonium Solution

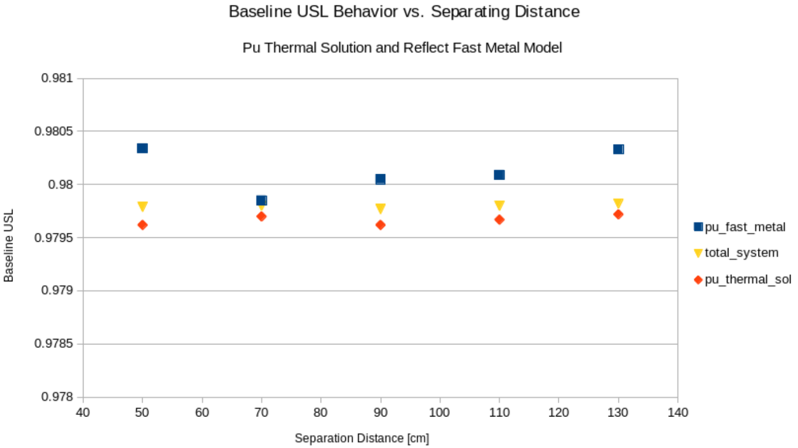
Separation Distance [cm]

Ranked Benchmark	50	70	90	110	130
1	pu-met-fast-044-004.i	pu-met-fast-042-002.i	pu-met-fast-044-004.i	pu-met-fast-044-004.i	pu-met-fast-044-004.i
2	pu-met-fast-044-005.i	pu-met-fast-042-003.i	pu-met-fast-044-005.i	pu-met-fast-044-005.i	pu-met-fast-044-005.i
3	pu-met-fast-024-001.i	pu-met-fast-044-005.i	pu-met-fast-042-002.i	pu-met-fast-042-002.i	pu-met-fast-031-001.i
4	pu-met-fast-036-001.i	pu-met-fast-027-001.i	pu-met-fast-042-001.i	pu-met-fast-031-001.i	pu-met-fast-024-001.i
5	pu-met-fast-031-001.i	pu-met-fast-044-004.i	pu-met-fast-031-001.i	pu-met-fast-042-001.i	pu-met-fast-036-001.i
6	pu-met-fast-044-003.i	pu-met-fast-042-001.i	pu-met-fast-042-003.i	pu-met-fast-042-003.i	pu-met-fast-042-001.i
7	pu-met-fast-042-002.i	pu-met-fast-042-004.i	pu-met-fast-027-001.i	pu-met-fast-027-001.i	pu-met-fast-044-003.i
8	pu-met-fast-042-001.i	pu-met-fast-011-001.i	pu-met-fast-011-001.i	pu-met-fast-042-004.i	pu-met-fast-042-002.i
9	pu-met-fast-027-001.i	pu-met-fast-042-005.i	pu-met-fast-042-004.i	pu-met-fast-036-001.i	pu-met-fast-027-001.i
10	pu-met-fast-042-004.i	pu-met-fast-031-001.i	pu-met-fast-036-001.i	pu-met-fast-011-001.i	pu-met-fast-011-001.i

Mixed Plutonium Model Results

Mixed Plutonium Model Ranked Benchmark	Separation Distance [cm] 50 cm	70 cm	90 cm	110 cm	130 cm
1	pu-sol-therm-001-001.i	pu-sol-therm-001-001.i	pu-sol-therm-001-001.i	pu-sol-therm-001-001.i	pu-sol-therm-001-001.i
2	pu-sol-therm-010-002.i	pu-sol-therm-010-002.i	pu-sol-therm-010-002.i	pu-sol-therm-010-002.i	pu-sol-therm-010-002.i
3	pu-sol-therm-010-009.i	pu-sol-therm-010-009.i	pu-sol-therm-010-009.i	pu-sol-therm-010-009.i	pu-sol-therm-010-009.i
4	pu-sol-therm-002-006.i	pu-sol-therm-002-005.i	pu-sol-therm-002-006.i	pu-sol-therm-002-005.i	pu-sol-therm-002-005.i
5	pu-sol-therm-002-005.i	pu-sol-therm-002-006.i	pu-sol-therm-002-005.i	pu-sol-therm-002-006.i	pu-sol-therm-002-004.i
6	pu-sol-therm-007-010.i	pu-sol-therm-002-004.i	pu-sol-therm-007-010.i	pu-sol-therm-002-004.i	pu-sol-therm-002-006.i
7	pu-sol-therm-002-004.i	pu-sol-therm-007-010.i	pu-sol-therm-002-004.i	pu-sol-therm-007-010.i	pu-sol-therm-007-010.i
8	pu-sol-therm-001-002.i	pu-sol-therm-001-002.i	pu-sol-therm-001-002.i	pu-sol-therm-002-003.i	pu-sol-therm-002-003.i
9	pu-sol-therm-007-005.i	pu-sol-therm-007-005.i	pu-sol-therm-002-003.i	pu-sol-therm-001-002.i	pu-sol-therm-001-002.i
10	pu-sol-therm-002-003.i	pu-sol-therm-002-003.i	pu-sol-therm-002-007.i	pu-sol-therm-002-007.i	pu-sol-therm-007-005.i

Mixed Plutonium Model Results



Reactivity and Sensitivity Profile Dominance

The region with the significantly higher calculated k_{eff} dominates the sensitivity profile which was used by Whisper to select a benchmark population and to determine the baseline USL for the loosely-coupled system.

This sensitivity profile dominance based upon a relatively small difference in the region's calculated k_{eff} values could potentially be caused by uncertainty in nuclear data. Thus, Whisper could select a benchmark population and determine a baseline USL inaccurately.

Model	Region 1	Region 2	Region 1 k_eff	Region 2 k_eff	|Δk_eff|
Bare Fast Metal Model	HEU Sphere	Plutonium Sphere	0.9998+/-0.0001	1.0001+/- 0.0001	0.0003+/-0.0002
Water-Reflected Fast Metal Model	Reflected HEU Sphere	Reflected Plutonium Sphere	0.99406+/-0.00011	1.00014+/-0.00011	0.0068+/-0.00022
Thermal Solution Model	HEU Solution	Plutonium Solution	0.99113+/-0.00015	1.00578+/-0.00013	0.01465+/-0.00028
Mixed Plutonium Model	Plutonium Solution	Reflected Plutonium Sphere	1.00578+/-0.00013	1.00002+/-0.00010	0.00576+/-0.00023

Conclusions

The results from the four numerical studies show that the coupled system sensitivity profile are usually dominated by a single assembly. Whisper's selected benchmark profile then reflects only the dominant assembly and the determined baseline USL is **not necessarily conservative**.

To insure that that the most conservative baseline USL is selected, it is recommended to calculate the regional baseline USL values and choose the more conservative value.

Future Work

The following items are being considered for future work:

The following steps outline the methodology of this study:

- Quantify the S_k as a function of the energy spectra and solid angle of the interacting neutrons
- Quantify the relationship between the difference in calculated k_{eff} values of the various regions in the loosely-coupled system and the dominance of a given sensitivity profile.
- Explore the use of EVT to develop a bounding benchmark population and determine the most conservative baseline USL
- Add the region-wise sensitivity profile capabilities to Whisper
- Explore more complicated loosely-coupled systems

References I

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Release Notes for Whisper-1.1.